MODEL 138

PULSE GENERATOR

E-H RESEARCH LABORATORIES, INC.
163 ADELINE STREET · OAKLAND 20, CALIFORNIA

AD A04 396

AD A04 396

MODEL 138

PULSE GENERATOR

TABLE OF CONTENTS

SPECIFICATIONS

OPERATING INFORMATION

THEORY OF OPERATION

CIRCUIT DESCRIPTION

APPLICATIONS

MAINTENANCE

PARTS LIST

SCHEMATICS

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E-H MODEL 138 PULSE GENERATOR

ERRATA

Make the following corrections in parts lists and schematics:

1. Change transistors Q101-102, 104-108, 202, 204-205 and 207 from 2N741 to 2N966, E-H Part No. 663-032.
2. Change diodes CR12, 15, 20-25, 101, 103, 202 and 210 from Q6-100 to ID5-050, E-H Part No. 376-040.
3. Change transistors Q402, 405, 305, and 308 from 2N1363 to 2N250/GP273, E-H Part No. 663-026.
4. Change transistors Q201, 206 from 2N741 to 2N1143, E-H Part No. 663-006.
5. Change resistors R403, 424 from 110Ω to 160Ω, ± 5%, 1/2W, carbon comp.
6. Change resistor R410 from 91Ω to 130Ω, ± 5%, 1/2W, carbon comp.
7. Change resistor R123 from 510Ω to 270Ω, ± 5%, 1/2W, carbon comp.
8. Change inductor L301 from 0.68μh to 0.33 μh, eliminate L302.
9. Change transistors Q109, 210, 301, 303-304, 306-307, 315-317 from 2N706B to 2N706A, E-H Part No. 663-022.
10. Change capacitor, C14 from 7-45pf to 7-100pf trimmer, E-H Part No. 332-003.
11. Add capacitor C206, 33pf disc ceramic, from collector of Q210 to ground.

WARRANTY

This instrument is guaranteed to be free of defects in materials and workmanship for a period of one year following delivery. Excluded items under this warranty are tubes, fuses, transistors, and diodes. In the event of failure, written notice of the nature of the trouble and the instrument serial number should be sent to the factory. E-H Research Laboratories, Inc., will then send instructions for component replacement or return shipment to the factory or local representative.

E-H MODEL 138
PULSE GENERATOR

SPECIFICATIONS

Repetition Rate: 300 cps to 10 mcs internal free running multivibrator. Zero to 10 mcs externally driven.

Rise and Fall Times: 10 nanoseconds, both positive and negative pulses when terminated in 50 ohms.

Output Amplitudes: 7.5 volts into 50 ohms, 15 volts open circuit, maximum.

Pulse Widths: 50 nanoseconds to 1 millisecond, continuously variable.

Pulse Delay: 50 nanoseconds to 1 millisecond with respect to the trigger output, continuously variable. An additional front panel selection provides ZERO delay so that the trigger and the output leading edge are in coincidence.

Polarities: Simultaneous positive and negative output pulses are available from separate connectors.

Duty Factor: 50 per cent up to 5 mc and then decreasing to 35 per cent at 10 mcs.

Output Impedance: 50 ohms.

Output Attenuators: Up to 100:1 continuously variable. Individual step attenuators for both the positive and negative outputs providing attenuation in steps of 1:1, 3:1, 10:1 and 30:1. A fine amplitude control, with a range of approximately 3-1/2:1, controls both outputs simultaneously.

Jitter: less than 0.1 per cent (includes pulse width, repetition rate and pulse delay jitter).

Trigger: For sync purposes, 5 volt positive pulse from 50 ohms output impedance, 10 nanosecond rise time, approximately 50 nanoseconds wide at half maximum amplitude.

External Drive: Direct coupled input. Minimum: 2 volt positive signal. Maximum: 15 volts. Input impedance 560 ohms.

Gate Input: Direct coupled input. Minimum: 3.5 volt positive signal required to block the pulse train. Maximum: 15 volts. Input impedance 300 ohms.

Dimensions:
Cabinet mounted: 6 inches high, 17 inches wide, 12 inches deep
Rack mounted: 7 inches high, 19 inches wide, 12 inches deep

Power Requirements: 105-125 volts, 50/60 cps, 35 watts (220 volt service also available).

Ambient Temperature: Maximum recommended 55° C.

Weight: 12 lbs., Net.

OPERATING INSTRUCTIONS

Range Selection

The FREQUENCY, DELAY and WIDTH controls are all adjusted in the same manner. The coarse control is set at the appropriate range setting, and the fine control permits continuous adjustment within the range.

The marker on the coarse knob sets on a line. The numbers on either side of the line indicate the limits of the range. The fine control permits overlap of the ranges by at least 10 per cent.

Amplitude and Attenuator Controls

The positive and negative outputs have independend step ATTENUATORS which are located directly above their respective output connectors. The markings on the ATTENUATOR scales are voltage ratios (not decibels).

The AMPLITUDE control is the vernier for the ATTENUATORS and simultaneously controls the positive and negative pulse amplitudes.

Output Termination

The output circuitry has been designed to deliver clean, symmetric pulses into a 50 ohm load impedance. The pulses have monotonic rise and fall times of less than 10 nanoseconds, with overshoot and droop of less than a few per cent (as viewed on a sampling scope). To preserve these pulse shapes, the output cables should have a characteristic impedance of 50 ohms and should be terminated with 50 ohm resistances. Note that the shunt capacitance from the probe of a Tektronix 541 scope is sufficient to distort the waveform even when the signal is observed across a 50 ohm resistance.

The maximum output amplitude with a 50 ohm termination is 7.5 volts. However, larger amplitude pulses up to 15 volts may be obtained by using a larger load resistance. The primary effect of the larger load resistance on the waveform is to increase the overshoot and fall time. Typically, if the termination is 200 ohms providing a 12 volt pulse, the overshoot is 10 per cent as viewed on a sampling scope.

AC Power

The AC toggle switch controls POWER to the instrument. The pilot light is a visual indication that voltage exists at the secondary of the power transformer. The 0.5 amp fuse is in the primary leg of the power transformer and provides protection of the instrument.

Instruments for domestic (U.S.A.) use are wired for 117 VAC primaries. However, the power transformer has a spare winding for 220 VAC applications. The color coding for the windings on the transformer for 117 and 220 VAC use is shown on Circuit Schematic D-10300. If the 220 VAC primary winding is used, the fuse should be changed to 0.25 amps.

External Drive

If it is desired to trigger the pulse generator only from an external signal, the FREQ. RANGE switch should be set at EXT. and the signal connected to the EXT. DRIVE INPUT connector. However, if it is desired to mix the external trigger with the internal free-running multivibrator trigger, the FREQ. RANGE switch should be changed to any other position.

The external drive input is directly coupled through a 750 ohm resistor to a tunnel diode. The tunnel diode will trigger on a slowly increasing dc voltage as well as at higher frequencies. The minimum input voltage of 2 volts positive is required to switch the tunnel diode over its 5 ma peak point. The maximum external signal of 15 volts is a conservative rating set by the maximum dissipation of the tunnel diode.

Gate Input

A positive 3.5 volt signal will block the output pulse train for as long as it appears at the GATE INPUT connector. This signal may be a positive dc voltage which is intermittently pulsed off by a negative pulse, or it may be random or repetitive positive pulses.

The GATE INPUT connector is directly coupled through a 200 ohm resistance to the base of a gating transistor. The maximum rating for the gate signal of 15 volts is a conservative figure set by the base to emitter dissipation of the gating transistor in a breakdown mode.

Trigger Output

The trigger output pulse coincides in time with the initiation of the delay generator. If the DELAY switch is in the ZERO position, the delay generator is bypassed; and the trigger will then be coincident with the leading edge of the output pulse. The TRIGGER OUTPUT cable should be terminated in 50 to 100 ohms to eliminate distortion of its waveform.

Duty Factor Effects

At duty factors approaching 50 per cent, the pulse width and delay will change with frequency. This effect is minimized if the FINE controls are rotated to their clockwise positions.

The output amplitude will drop by approximately 4 per cent as the duty factor is increased from a very low value to 50 per cent.

THEORY OF OPERATION

A simplified block diagram of the Model 138 Pulse Generator is shown in Figure 1. More detailed block diagrams are shown on the schematics at the back of this manual. Reference to these block diagrams is made in the following discussion.

A free-running multivibrator controls the repetition rate of the output pulse train. The leading edge of this multivibrator is differentiated and passed through a gate to trigger a delay one-shot. The free-running multivibrator may be made inoperative, and an external drive signal will then control the output repetition rate.

The gate is normally open; that is, the trigger pulses will pass through it unless an external gate signal is applied to it. Then the gate will be closed for as long as the external signal is present.

The output of the gate either triggers the delay one-shot or is bypassed to the width one-shot by the zero-delay position.

The pulse that triggers the delay one-shot is also amplified and made available for external sync purposes.

The delay one-shot generates an output pulse whose trailing edge is differentiated to become the trigger for the width one-shot. The output of the width one-shot is applied to the input of a current switch which is a circuit similar to a difference amplifier.

The current switch has complementary outputs which are then applied to emitter followers which deliver the positive and negative output pulses. A more detailed circuit description follows in Section 5.

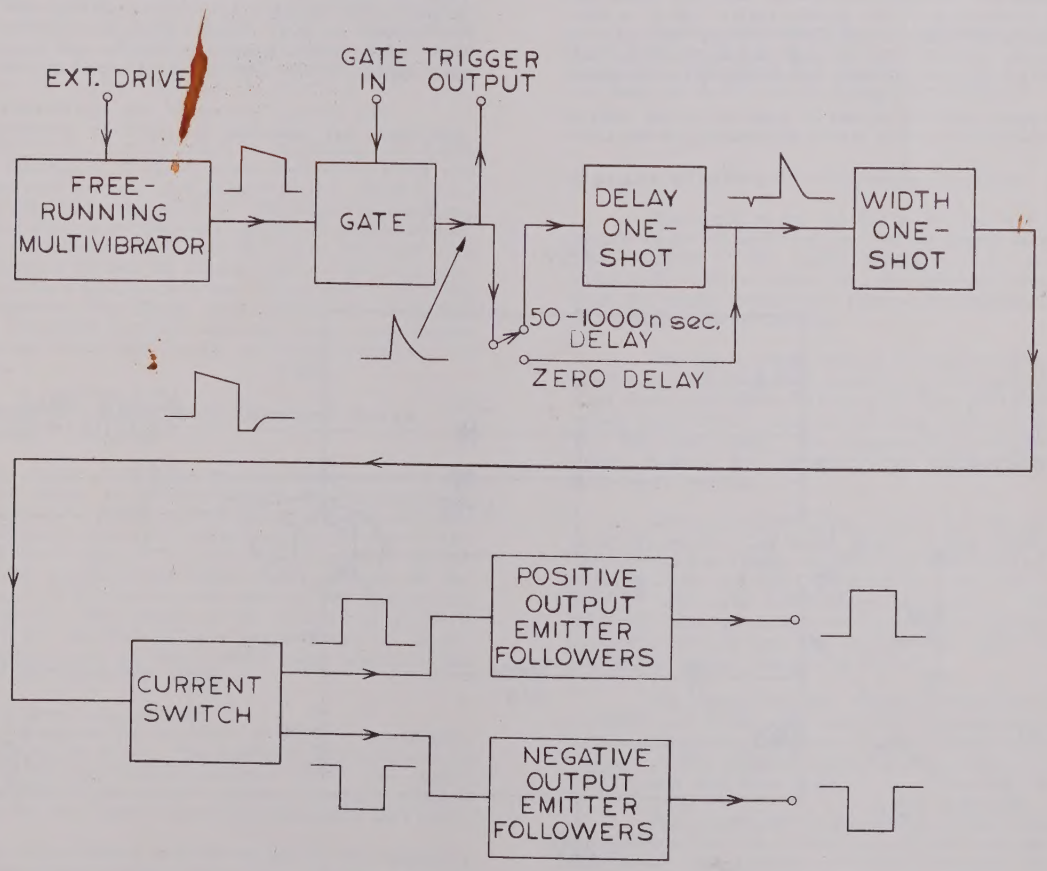

Figure 1

CIRCUIT DESCRIPTION

The instrument is physically separated into five printed boards as follows:

Board 1: Multivibrator, Gate and External Drive (Schematic D-10296).

Board 2: Delay and Width One-shots (Schematic D-10297).

Board 3: Output Circuitry (Schematic D-10298).

Board 4: Power Supply Regulators (Schematic D-10299).

Board 5: Connector Board (Schematic D-10300).

The circuit schematics for each of these boards are shown in the back of this manual. (The schematics for the front panel and the unregulated power supplies are shown with Board 5.) These physical divisions are also convenient functional divisions for describing the circuits in the following text; but first, it is desirable to give a separate detailed discussion of the timing circuits common to Boards 1 and 2.

Timing Circuits

The timing circuits used in this instrument are emitter coupled one-shots with the basic configuration shown below in Figure 2. Both Q-1, Q-2 and CR-2 are normally conducting in the stable state. CR-1 is normally non-conducting. Diode CR-2 clamps the collector of Q-1 to -2.5 volts. The current coming from the collector of Q-1 divides between R2 and CR-2 in this state.

When a positive signal is applied to the base of Q-1, its collector current starts decreasing, diode CR-2 unclamps and the collector starts a negative excursion. This negative going waveform appears at the base of Q-2 and, through emitter-follower action, at the emitter of Q-2. The negative going edge is then transmitted through R4 and C1 to the emitter of Q-1 which aids the trigger in further decreasing the current in Q-1. Through regenerative action, Q-1 becomes cut-off; and its collector drops to a clamped level determined by CR-1 and the adjustable -4.5 to -12 volt supply. The time during which CR-1 clamps the collector of Q-1 is termed the quasi-stable state.

During the quasi-stable state, the negative pulse at the base and emitter of Q-2 produces a positive pulse at the collector which is the output or timing pulse.

The timing period or length of the quasi-stable state is determined by the value of C1 and the voltage on CR-1. During this state, C1 becomes charged up through R3 until the voltage at the emitter of Q-1 is sufficient to turn Q-1 back into conduction. An approximation for the time of the quasi-stable state is

$$\text{Time} = \frac{C1 \times E}{I}$$

where C1 is the value of the timing capacitor, E is the amplitude of the excursion between the voltage on CR-1 and CR-2 and I is the charging current in R3.

As Q-1 starts to conduct at the end of the quasi-stable state, CR-1 unclamps and the collector starts a positive excursion. The positive going edge is transmitted to the emitter of Q-2 and through R4 and C1 to the emitter of Q-1. This further accelerates the process, regeneration again takes place and the collector of Q-1 rapidly rises until it is clamped by CR-2.

The timing period of the quasi-stable state is now over, but capacitor C1 must be discharged before

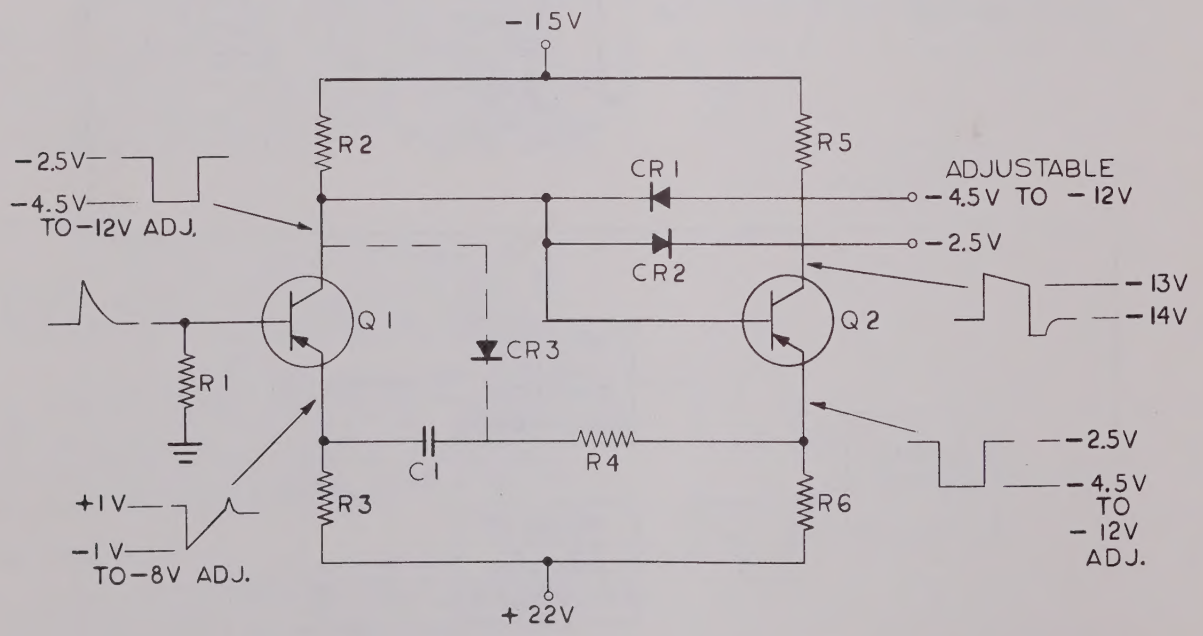

Figure 2

the circuit is ready to receive another trigger pulse. The time during which C1 discharges is termed the recovery period. The recovery current into C1 comes from the 22 volt supply through R4 and R6. During this time, the current that had been going into the emitter of Q-2 is diverted into C1; and Q-2 becomes cut off. The function of diode CR-3 is to hasten the recovery time, and it is non-conducting during the stable and quasi-stable states.

The presence or absence of R4 in Figure 2 is the major difference between the free-running multivibrator and the one-shots. CR-2 is insufficient alone, because of its finite forward resistance, to keep the one-shots stable. The shunt of CR-2 and the series resistance of R5 in the feedback loop is necessary for stability.

Reference to the free-running multivibrator in Schematic No. D-10296 at the end of the manual will show that there is no resistor in series with the timing capacitor which helps to insure the necessary conditions for free-running operation of the multivibrator. The recovery diode CR-3 is not required in this circuit. Aside from the presence of CR-3 and R4, the description of the circuit operation of the one-shots applies also to the free-running multivibrator.

Reference to the detailed schematics of the timing circuits will show components additional to those in Figure 2. Diodes in series with the emitters are present to control the breakdown of the base to emitter junctions when the transistors are cut-off. The adjustable supply voltage which controls the amplitude of the voltage swing during the quasi-stable state is provided by emitter followers. These emitter followers function as the fine control for all the timing circuits. (The capacitors are, of course, the coarse control.)

Reference, in particular, to the Delay and Width One-shot Schematic D-10297 shows resistors R208 and R224 connected between the outputs of the emitter followers and the clamping diodes. These aid in initiating fast regeneration from the quasi-stable to stable states. In addition, resistors R203 and R219 add forward bias to the recovery diodes to further hasten the recovery time. Resistors such as R15 and R19 in series with the timing capacitor (see Front Panel Schematic D-10300) limit the recovery current into the small capacitors; which current may lead, under certain conditions, to instability.

Multivibrator, Gate and External Drive

(See Schematic D-10296)

The output of the free-running multivibrator, the collector of Q102, is differentiated and passes through diode CR106 to the emitter of the gating transistor Q104. This transistor is normally biased on by 0.6 volts across CR109. For as long as no gate signal appears at the base of Q104, an amplified output pulse appears at the collector and is directed to the base of the degenerate amplifier Q106. The output at the emitter of Q106 is the trigger for the Delay One-shot on Board 2. (If the Delay Switch is set at Zero, this pulse becomes the trigger for the Width One-shot).

The output at the collector of Q106 is simultaneously amplified by Q108. The output at the collector of Q108 is fed into the emitter follower Q109. The signal appearing at the emitter of Q109 passes through a 33 ohm resistor to the front panel connector TRIGGER OUTPUT.

The output pulses of Q106 and Q109 will cease if a positive gate pulse appears at the base of Q104. A minimum amplitude of 3.5 volts positive at the front panel GATE INPUT connector is required to bias off Q104.

If a positive pulse with a minimum amplitude of 2 volts is applied to the front panel EXT. DRIVE connector, it will pass through the 750 ohm resistor R134 to trigger the tunnel diode CR111. The output of the tunnel diode is differentiated and amplified by Q107 and Q105 and then passes through CR107 to the emitter of the gating transistor Q104. Diodes CR107 and CR106 function as an "OR" circuit. Therefore, the internal free-running multivibrator trigger and the external drive trigger may be made to appear at the emitter of Q104 simultaneously or separately.

Delay and Width One-shots Schematic D-10297)

The operation of the Delay and Width One-shots has been described above under "Timing Circuits". The interconnection of these two one-shots and the shaping of the output pulse for this board will now be described.

An input trigger pulse causes regenerative action of the Delay One-shot, Q201 and Q202. The output of the Delay One-shot at the collector of Q202 is differentiated and amplified by Q204. The output of Q204 is fed into the emitter follower Q205 which in turn triggers the Width One-shot. Also note that the "zero delay" pulse arrives at the base of Q205 if the Delay One-shot is bypassed.

The output of the Width One-shot at the collector of Q207 is capacitively coupled into the emitter of the common base amplifier Q209. The output of Q209 is capacitively coupled to emitter follower Q210. The pulse appears at the emitter of Q210 and passes through a 33 ohm resistor to the next board.

Emitter follower Q211 supplies a necessary dc bias level for the base of Q210. Emitter follower Q212 supplies a bias level for squaring the top of the pulse at the base of Q210 (via clamping diode CR217).

Output Cicuitry (See Schematic D-10298)

The input pulse (at Pin 3) to this board has the required delay and width as set by antecedent controls. The function of the output circuitry is to increase its amplitude and decrease its rise time and then to direct it to the output connectors from a low impedance source. The process is as follows.

The input pulse passes through emitter follower Q301 and appears at the bases of the biased off transistors Q303 and Q304. Q303 and Q304 are thought of as being one-half of a current switch, while Q306 and Q307 are the other half. The transistors are paralleled on either side of the current switch so as to provide the necessary wattage.

Q306 and Q307 are conducting before the input pulse appears. The input pulse drives Q303 and Q304 into conduction, their emitters go positive and the emitters of Q306 and Q307 go positive with respect to their bases. Q306 and Q307 cease to conduct. The current that had been going into the emitters of Q306 and Q307 is now switched into the emitters of Q303 and Q304; hence the name "current switch".

The voltage at the common collector connection of Q303 and Q304 then falls; and when the pulse at their bases disappears, they rise again. Simultaneously, the voltage at the common collector connection of Q306 and Q307 rises and then falls.

The amplitude of the swing at the collectors is proportional to the amount of current injected into the emitters. The bottom end of the emitter resistances, R310 and R311, are connected to the emitter of Q305, an emitter follower. The voltage on the base of this emitter follower is controlled by the front panel AMPLITUDE control. In this manner, a continuous fine control of the amplitude at the output of the current switch is obtained.

The function of transistors Q308, Q309 and Q311 is to reduce the collector voltages of the current switch transistors as the emitter current is reduced. If this servo type of control were not present, there would be very large voltages across the collector to emitter junctions at reduced emitter currents -- leading to excessive power dissipation. The COLLECTOR VOLTAGE trimpot's function is to adjust the collector-emitter voltage of Q306 and Q307 to approximately 2 volts at maximum current.

The BASE DRIVE trimpot's function is to set the base line on which the input pulse rides (at the base of Q303 and Q304). If the base line is too far negative, the input pulse will not drive Q303 and Q304 into conduction or it may be driven only partially into conduction resulting in a poor rise time. If the base line is too close to ground, the transistors may saturate when switching, leading to a poor pulse shape. A collector to emitter voltage of 2 volts is most satisfactory for Q303 and Q304 during the switching operation.

The outputs of the current switch (common collector connections) are then transmitted through capacitances and inductances L303 and L304 (for compensation) to the common base connections of the output emitter followers, Q312 through Q317. Here again, transistors are paralleled to obtain the necessary wattage requirements.

The collectors of the output emitter followers are coupled (through resistors) to the adjustable buses that supply the voltages for the current switch. This is also done to keep the dissipation of the transistors low.

The emitters of the output emitter followers are tied together through 10 ohm resistors to equalize the differences between their Betas. Each of the three transistors in the positive and negative emitter followers supply one-third of the output current. The output currents join together at the junction of the three 10 ohm resistors and then pass through the 39 ohm "back-matching" resistor to the output attenuators. From the output attenuators, the signals then appear at the front panel POSITIVE OUTPUT and NEGATIVE OUTPUT connectors.

Connector Board and Front Panel

(See Schematic D-10300)

This schematic shows the wiring between Boards 1 to 4 and the front panel wiring diagram. In addition, the wiring of the unregulated supplies (which are mounted on a sub-assembly on the cabinet frame) is shown.

The unregulated supplies have full-wave rectifiers with capacitor input filters. The 28 VAC rating of the secondaries of the transformers is at full load.

Power Supplies

(See Schematic D-10299)

The Model 138 requires five power supply buses: plus 22 volt, negative 22 volt, negative 15 volt, negative 7.5 volt and negative 2.5 volt. The negative 2.5 volt and 7.5 volt are low current bias supplies developed by emitter followers. The voltage for these supplies comes from the regulated negative 15 volt bus.

The feedback regulator for the plus 22 volt, negative 22 volt and the negative 15 volt bus function as follows.

Refer to the negative 22 volt regulator. The output voltage is sampled at the base of Q403 and compared with the zener voltage at the emitter. If the voltage tends to go positive or negative, the collector current of Q403 changes thereby changing the base current of the series transistor Q402. The emitter current of Q402 then changes in the direction to offset the change that started to appear at the output.

The function of Q401 is to present a large load resistance to the collector of Q403, thereby maximizing the feedback gain.

The trimpot at the base of Q403 is provided to compensate for component tolerances so that the output voltage will be exactly 22 volts. The negative 22 volt and negative 15 volt regulators function in a similar manner.

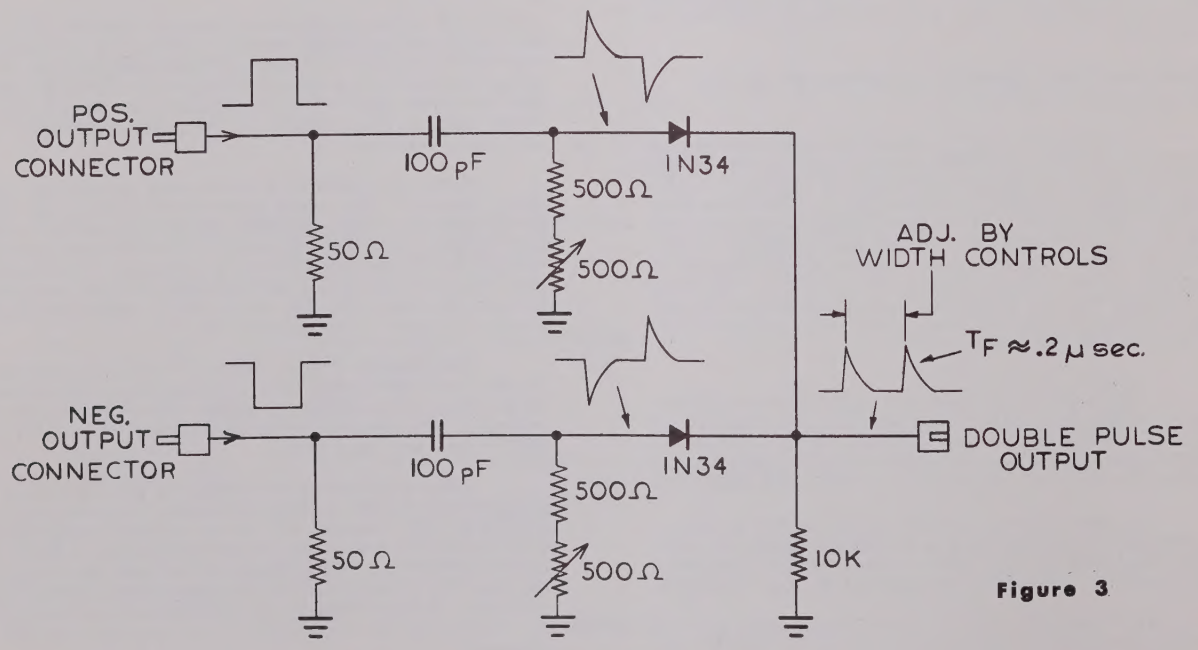

Figure 3

APPLICATIONS

The usual applications of the Model 138 Pulse Generator are described in Section 2, Operating Information. In this section are discussed more specialized applications, some of which require slight modifications or additions to the instrument.

A. Double Pulse Generator -- Internal Modification:

Referral to the block diagram, Figure 1, shows that the trigger signal coming from the gate is fed into the Delay or Width One-shots. A double pulse output may be obtained by triggering the Delay and Width One-shots simultaneously. This is accomplished by connecting a .01 μf capacitor across the switch which normally selects either one-shot. The separation between the pulses is adjustable by the DELAY controls.

It is convenient to insert a toggle in series with the above mentioned capacitor for single pulse or double pulse operation. However, if the capacitor is connected permanently, the ZERO position of the DELAY switch will provide single pulse operation and the other positions will produce a double pulse. The minimum separation between the double pulses is approximately 100 nanoseconds.

B. Double Pulse Generator -- External Modification:

In this application, both the positive and negative output pulses are differentiated. Then the leading edge of the positive pulse and the trailing edge of the negative pulse (or vice versa) are fed together through diodes. The separation between the two positive (or negative) pulses is adjusted by the WIDTH controls. The DELAY controls adjust the delay to the first pulse. This modification is shown in Figure 3.

The relative amplitude of the two pulses may be controlled by the front panel ATTENUATORS and the 500 ohm potentiometers in Figure 3. The minimum separation between the pulses is approximately 50 nanoseconds. This application is particularly useful in testing the resolution of scalers and discriminators.

C. Random Pulse Generator:

In this application, a sine wave or pulse generator signal is fed into the EXT. DRIVE connector. The FREQ. RANGE switch is positioned out of the EXT. location. The triggers from the internal free-running multivibrator and the external drive are thereby mixed at random. It is often convenient to gate on and off this random pulse rate by supplying a signal to the GATE connector. This application is particularly useful in checking baseline shifts in amplifiers which are used with pulsed accelerators.

D. Rise Time Control:

Many types of passive circuits are used to degrade rise time, but one of the simplest is an R-C integrator as shown in Figure 4. The rising and falling edges may have slight bumps due to mismatching effects.

The rise and fall time for the values shown in Figure 4 is 60 nanoseconds. Different values of capacitance may be shunted in by a rotary wafer switch to vary the rise times.

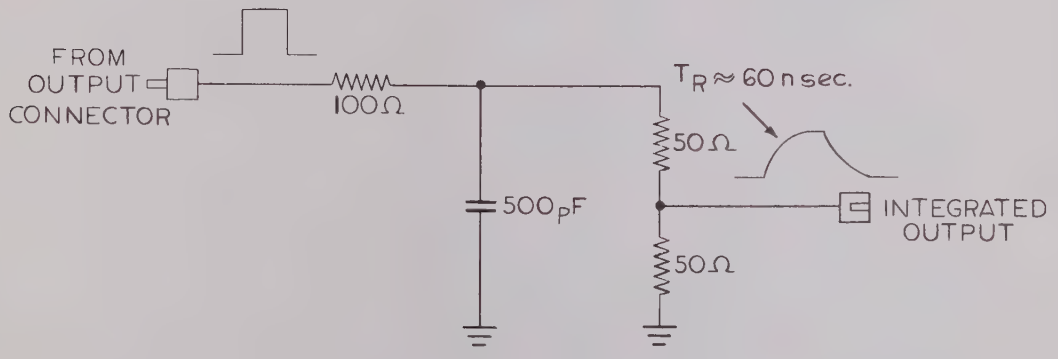

Figure 4

MAINTENANCE

Removal of Cover

It is necessary to remove the top and bottom cover of the instrument to make adjustments. The bottom and top covers are held in place by eight screws located on the bottom of the cabinet. The bottom cover falls out of place when its four screws are removed. The top cover has a tongue which overlaps the bottom of the frame. These tongues must be pried slightly outwards and upwards to lift the cover off the frame. The top cover is designed to be flexed, and it will not be marred if this removal is done with reasonable care.

Supply Voltages

The plus 22 volt, minus 22 volt and minus 15 volt buses are adjusted by trimpots R426, R405 and R412 located on the Power Regulator Board. The location of these controls is shown on Schematic D-10299. If for any reason these voltages change (due to component replacement or long term drift), they should be readjusted to the prescribed voltages. Convenient test points for measuring these voltages are shown on the photograph of this board in Figure 8. Be careful not to short these test points to ground as it is possible to damage components without blowing the fuse.

Output Circuitry

Located on the output board are two adjustment trimpots; Collector Voltage, R332, and Base Drive, R304. Their placement is shown on the outline on Schematic D-10298. Their functions have been described in Section IV under Output Circuitry. The following adjustments are made with the instrument operating at a low duty factor and a 50 ohm output load.

Collector Voltage Adjustment: Connect a scope probe to the common collector junction of Q306 and Q307. This is test point A as shown on the photograph in Figure 7. The scope should be direct coupled to this point and the amplitude control set at maximum. The dc voltage at these collectors in between pulses should be approximately +1.5 volts. The waveforms should appear as shown on the schematic at this point. Then the amplitude control should be reduced, and the baseline should rise to not more than +4 volts at minimum amplitude.

Base Drive Adjustment: Connect a scope probe (direct coupled) to the common junction of the bases of Q303 and Q304. This is test point B as shown on the photograph in Figure 7. Set the amplitude control at maximum. Adjust the base drive control until the top of the pulse is about 1.5 volts above ground as shown on the schematic. Then examine the waveform at the common collector junction of Q303 and Q304. This is test point C on the photograph. The collector voltage during the pulse should drop to about 3 volts above ground. Reduce the amplitude control and make sure that the collector voltage does not saturate at minimum amplitude. If necessary, readjust the base drive.

The base drive adjustment controls the quality of the output waveforms and may best be made while observing the output on a sampling oscilloscope as the amplitude control is varied. The main aim of the above adjustments is to keep the dissipation of the transistors low while obtaining the fastest rise and fall times and flat top on the output pulses.

Service

If service on the instrument is required, reference should be made to the schematics which include waveforms, voltages and block diagrams. Reference should also be made to the Circuit Description in Section IV.

Generally, the printed boards may be checked with the top and bottom covers removed as described above in Section V. However, if it is desirable to place the boards on an extension, the back panel may be taken off by removing the four corner screws. The back panel serves the function of clamping the printed boards in place. An extension board is supplied with each instrument.

In case of failure or improper operation, check all supply voltages first. Then circuit trace the instrument starting with the free-running multivibrator on Board 1 through to the outputs. The transistor locations are shown in the photographs of Figures 5 to 8.

Take special note of the minimum pulse amplitudes specified at various places on the schematics. If a problem is localized to one board, the transistors should be removed and checked for Ico and Beta. However, even if the tester checks the transistors as being good, this is not conclusive proof that they are performing satisfactorily with higher wattages. Direct substitution of another transistor, even one from another part of the instrument, is a further good check.

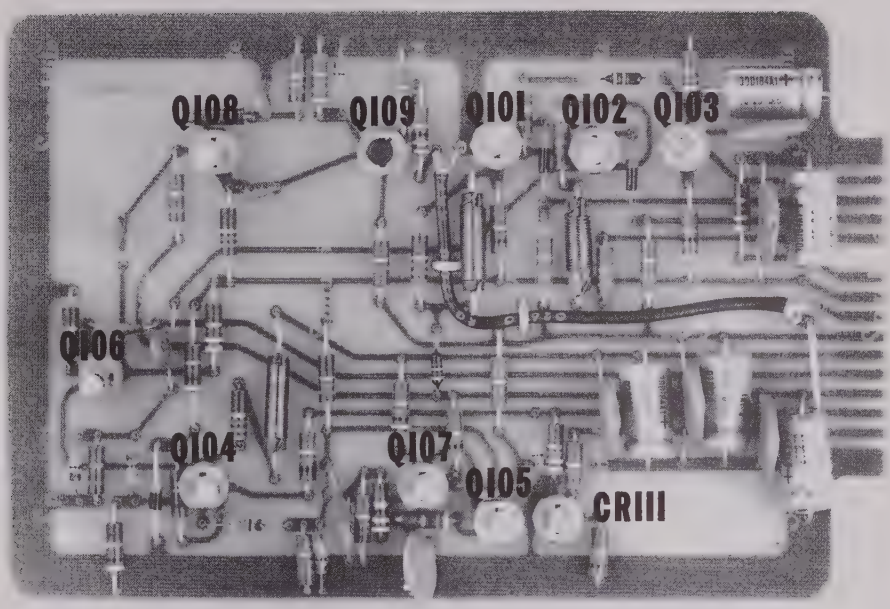

FIGURE 5 D-10296 Multi, Gate and Ext Drive

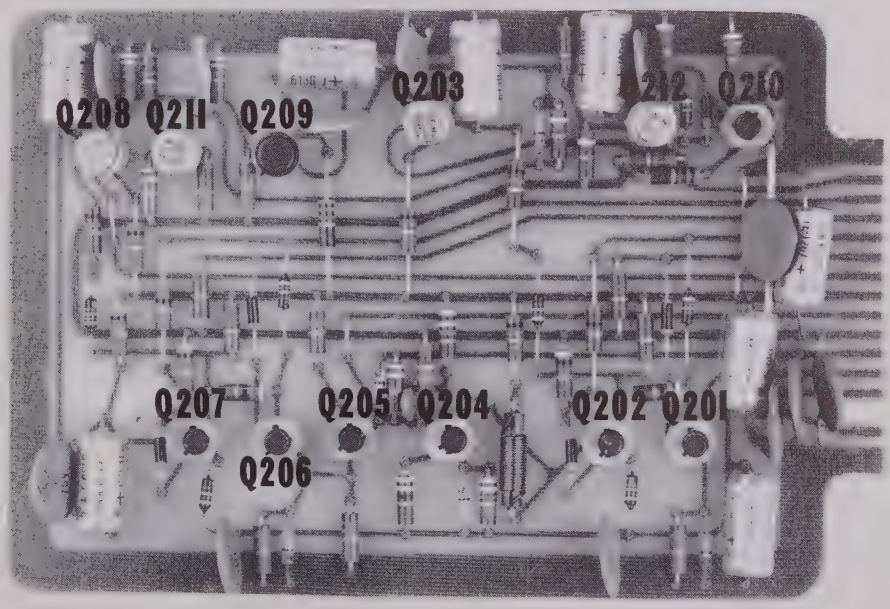

FIGURE 6 D-10297 Delay and Width One-shots

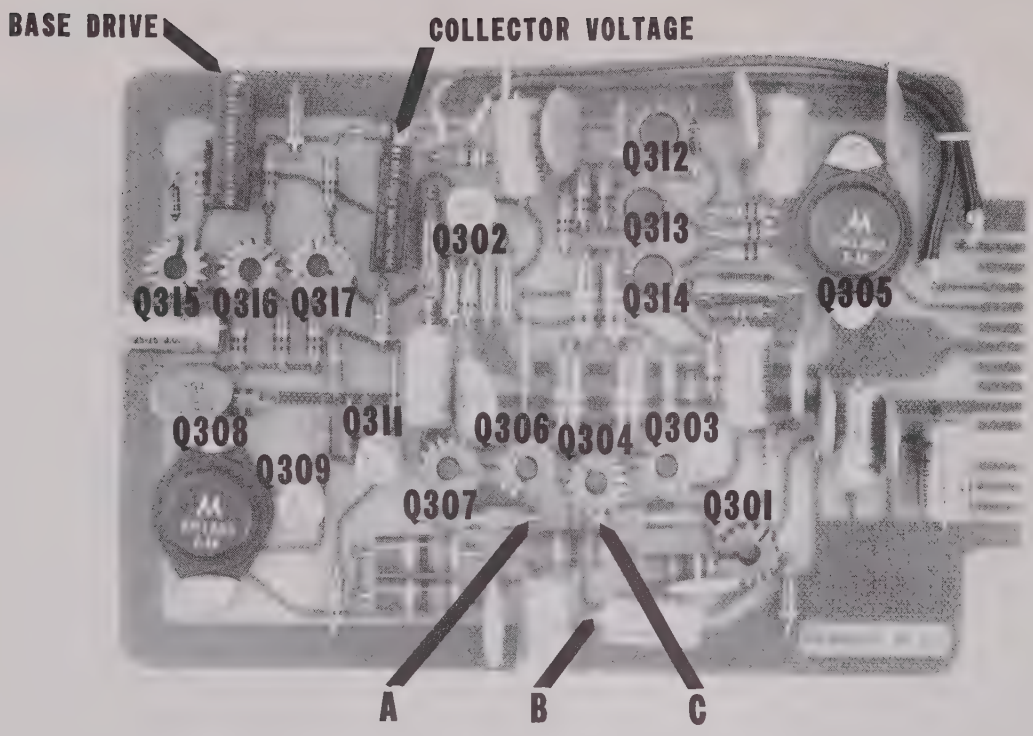

FIGURE 7 D-10298 OUTPUT CIRCUITRY

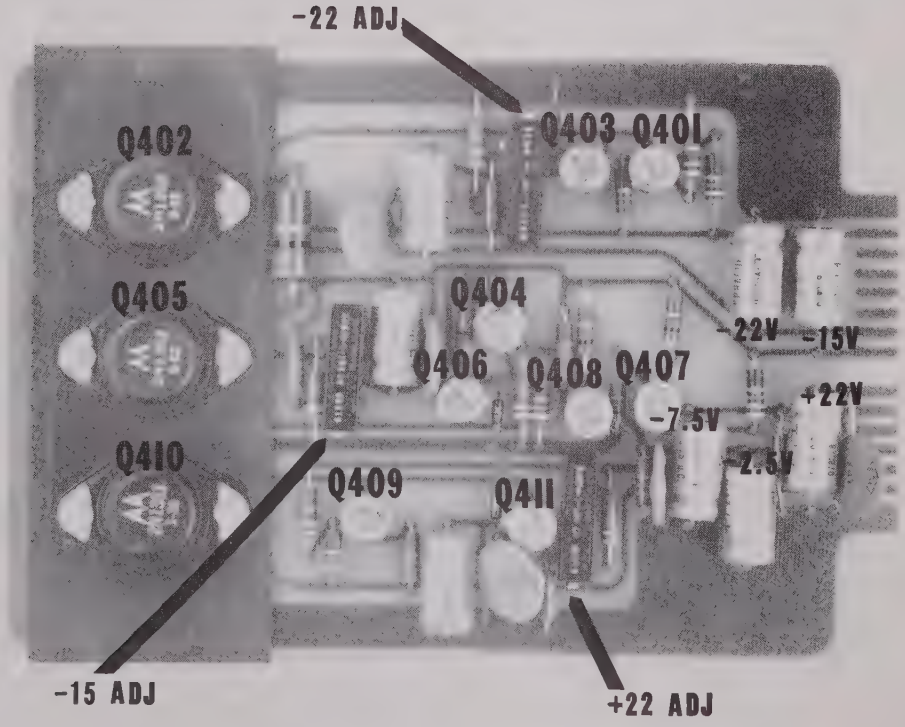

FIGURE 8 D-10299 POWER REGULATORS

PARTS LIST

ABBREVIATIONS

cer	ceramic	K	kilohm
comp	composition	p	pico
emc	electrolytic, metal cased	u	micro
f	farad	v	working volts DC
myl	mylar capacitor	w	watts

CAPACITORS

C1-C4	250uf	50v	fixed	emc	-20+40%
C5	2.5uf	200v	fixed	myl	5%
C6	0.7uf	200v	fixed	myl	5%
C7	0.25uf	200v	fixed	cer	5%
C8	0.07uf	200v	fixed	cer	5%
C9	0.025uf	200v	fixed	cer	5%
C10	0.007uf	200v	fixed	cer	5%
C11	0.0025uf	200v	fixed	cer	5%
C12	600pf	200v	fixed	cer	-20+80%
C13	100pf	200v	fixed	cer	-20+80%
C14-C15	7-45pf	200v	var.	cer	
C16	150pf	200v	fixed	cer	-20+80%
C17	500pf	200v	fixed	cer	-20+80%
C18	0.002uf	200v	fixed	cer	5%
C19	0.006uf	200v	fixed	cer	5%
C20	0.02uf	200v	fixed	cer	5%
C21	0.06uf	200v	fixed	cer	5%
C22	0.2uf	200v	fixed	cer	5%
C23	0.6uf	200v	fixed	cer	5%
C24	2.0uf	200v	fixed	myl	5%
C25	7-45pf	200v	var.	cer	
C26	150pf	200v	fixed	cer	-20+80%
C27	500pf	200v	fixed	cer	-20+80%
C28	0.002uf	200v	fixed	cer	5%
C29	0.006uf	200v	fixed	cer	5%
C30	0.02uf	200v	fixed	cer	5%
C31	0.06uf	200v	fixed	cer	5%
C32	0.2uf	200v	fixed	cer	5%
C33	0.6uf	200v	fixed	cer	5%
C34	2.0uf	200v	fixed	myl	5%
C101	100pf	200v	fixed	cer	-20+80%
C102	.1uf	200v	fixed	cer	-20+80%
C103	25uf	25v	fixed	emc	-20+80%
C104	500pf	200v	fixed	cer	-20+80%
C105	.01uf	200v	fixed	cer	-20+80%
C106-107	.001uf	200v	fixed	cer	-20+80%
C108	250pf	200v	fixed	cer	-20+80%
C109	150pf	200v	fixed	cer	-20+80%
C110	250pf	200v	fixed	cer	-20+80%
C111	500pf	200v	fixed	cer	-20+80%
C112-115	.1uf	200v	fixed	cer	-20+80%
C116-119	25uf	25v	fixed	emc	-20+80%
C201	.05uf	200v	fixed	cer	-20+80%
C202	50pf	200v	fixed	cer	-20+80%
C203	.01uf	200v	fixed	cer	-20+80%
C204	25uf	25v	fixed	emc	-20+80%
C205	.001uf	200v	fixed	cer	-20+80%
C206	Not used.				
C207	.001uf	200v	fixed	cer	-20+80%
C208	.01uf	200v	fixed	cer	-20+80%
C209	.1uf	200v	fixed	cer	-20+80%
C210	25uf	25v	fixed	emc	-20+80%
C211	.01uf	200v	fixed	cer	-20+80%
C212	25uf	25v	fixed	emc	-20+80%
C213	.1uf	200v	fixed	cer	-20+80%
C214	25uf	25v	fixed	emc	-20+80%
C215-217	.1uf	200v	fixed	cer	-20+80%
C218-220	25uf	25v	fixed	emc	-20+80%
C221-222	.1uf	200v	fixed	cer	-20+80%
C223	.01uf	200v	fixed	cer	-20+80%
C224	25uf	25v	fixed	emc	-20+80%
C301	.01uf	200v	fixed	cer	-20+80%
C302	25uf	25v	fixed	emc	-20+80%

C303	.1uf	200v	fixed	cer	-20+80%
C304-305	25uf	25v	fixed	emc	-20+80%
C306	.1uf	200v	fixed	cer	-20+80%
C307	25uf	25v	fixed	emc	-20+80%
C308	.1uf	200v	fixed	cer	-20+80%
C309	25uf	25v	fixed	emc	-20+80%
C310	.1uf	200v	fixed	cer	-20+80%
C311	25uf	25v	fixed	emc	-20+80%
C312	.1uf	200v	fixed	cer	-20+80%
C313	25uf	25v	fixed	emc	-20+80%
C314-315	.1uf	200v	fixed	cer	-20+80%
C316-318	25uf	25v	fixed	emc	-20+80%
C319	.1uf	200v	fixed	cer	-20+80%
C401	25uf	25v	fixed	emc	-20+80%
C402	.1uf	200v	fixed	cer	-20+80%
C403-404	25uf	25v	fixed	emc	-20+80%
C405	.1uf	200v	fixed	cer	-20+80%
C406	25uf	25v	fixed	emc	-20+80%
C407	.1uf	200v	fixed	cer	-20+80%
C408	25uf	25v	fixed	emc	-20+80%
C409	.1uf	200v	fixed	cer	-20+80%
C410-411	25uf	25v	fixed	emc	-20+80%
C412	.1uf	200v	fixed	cer	-20+80%
C413	25uf	25v	fixed	emc	-20+80%

CHOKES

L101	2.4 uh	Miller
L102	.68 uh	Miller
L103	8.2 uh	Miller
L201 & L301	.68 uh	Miller
L302	.33 uh	Miller
L303-304	.68 uh	Miller

DIODES

CR1-8	1N2071	Texas Instr.
CR101	Q6-100	International
CR102	1N914B	Texas Instr.
CR103	Q6-100	International
CR104	1N914B	Texas Instr.
CR105-108	1N270	Sylvania
CR109	1N2071	Texas Instr.
CR110	1N270	Sylvania
CR111	1N2941	Gen.Electric
CR112	1N270	Sylvania
CR201	1N270	Sylvania
CR202	Q6-100	International
CR203-204	1N914B	Texas Instr.
CR205	Not used	
CR206	1N914B	Texas Instr.
CR207-209	1N270	Sylvania
CR210	Q6-100	International
CR211-212	1N914B	Texas Instr.
CR213	Not used	
CR214-215	1N914B	Texas Instr.
CR216	Not used	
CR217	1N914B	Texas Instr.
CR301-303	1N914B	Texas Instr.
CR401-403	1/4M12Z5	Motorola

Note: Replacement chokes, diodes and transistors must be from manufacturer shown to insure proper operation.

RESISTORS

NOTE: All resistors shown on the schematics which are not listed below are 1/2 watt, ±5%, fixed, carbon composition.

R1-4	5 ohm	5%	3w	Fixed, comp.
R5	1 K		2w	Variable
R7	1 K		2w	Variable
R10	1 K		2w	Variable
R13	1 K		2w	Variable
R23	27 ohm	5%	1w	Fixed, comp.
R304	500 ohm		2w	Variable
R308	51 ohm	5%	1w	Fixed, comp.
R309	62 ohm	5%	2w	Fixed, comp.
R310-311	100 ohm	5%	1w	Fixed, comp.
R321	39 ohm	5%	1w	Fixed, comp.
R322-323	200 ohm	5%	2w	Fixed, comp.
R324-325	82 ohm	5%	2w	Fixed, comp.
R326	11 ohm	5%	1w	Fixed, comp.
R332	500 ohm		2w	Variable
R341	39 ohm	5%	1w	Fixed, comp.
R405	1 K		2w	Variable
R407	22 ohm	5%	2w	Fixed, comp.
R412	1 K		2w	Variable
R426	1 K		2w	Variable

TRANSISTORS

Q101-102	2N741	Motorola
Q103	2N1303	Texas Instr.
Q104-108	2N741	Motorola
Q109	2N706B	Motorola
Q201	2N1143	Motorola
Q202	2N741	Motorola
Q203	2N1303	Texas Instr.
Q204-205	2N741	Motorola
Q206	2N1143	Motorola
Q207	2N741	Motorola
Q208	2N1303	Texas Instr.
Q209	2N1143	Motorola
Q210	2N706B	Texas Instr.
Q211-212	2N1302	Texas Instr.
Q301	2N706B	Texas Instr.
Q302	2N1303	Texas Instr.
Q303-304	2N706B	Texas Instr.
Q305	2N1363	Motorola
Q306-307	2N706B	Texas Instr.
Q308	2N1363	Motorola
Q309	2N1302	Texas Instr.
Q310	Not used	
Q311	2N1302	Texas Instr.
Q312-314	2N1143	Motorola
Q315-317	2N834	Texas Instr.
Q401	2N1302	Texas Instr.
Q402	2N1363	Motorola
Q403	2N1303	Texas Instr.
Q404	2N1302	Texas Instr.
Q405	2N1363	Motorola
Q406-408	2N1303	Texas Instr.
Q409	2N1302	Texas Instr.
Q410	2N1363	Motoroia
Q411	2N1303	Texas Instr.

REVISIONS						
LTR	DESCRIPTION	DATE	DRAWN	CHK'D	APP'D	E.O.
A	RELEASED	7-1-61				
B	R123 VALUE CHANGE	8-15-61				

PROPRIETARY INFORMATION
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TITLE

D-10296 B

SHEET NO. 1 OF

.8 TO 4.2 μs ADJ.
-2V
-4V TO -11V ADJ.
-12 TO -11V
-15V
L102 .68 μH
R101 1K
R105 150Ω
R109 91Ω
R110 560Ω
Q103 2N1303
⑥ TO FINE FREQ. POT.
-2.5V TO -0V
R104 75Ω
CR104 IN914B
R108 240Ω
C 02 .1
C103 25 μF 25V
R111 330Ω
Q101 2N741
R103 1.01
R102 2.7K
Q102 2N741
CR102 IN914B
C101 100pF
CR101 G6-100
CR103 G6-100
⑭ ⑮ TO FREQ. CAPS. ON S-1
R107 5.1K
CR105 IN270
R106 2.7K
+1V
-1V TO -7V ADJ.
.8 TO 4.2 μs ADJ.
-2.3V
-3.8V TO -11V ADJ.
+2V TO +3V
0V
40nsec
CR106 IN270
CR107 IN270
R112 5K
R113 5.1K
CR108 IN270
C104 500pF
-11.5V
-13V
40nsec
1.5V min.
L103 8.2 μH
R115 3K
R114 680Ω
-3.5 TO -4.5V
-7.5V
40nsec
R119 560Ω
Q106 2N741
R123 270Ω
-0.62V
CR109 IN2071
R116 1K
R117 200Ω
Q104 2N74
R118 330Ω
④ GATE INPUT
CR110 IN270
-10V
-13V
50nsec
R122 390Ω
C107 .001
C106 .001
⑥ OUT PUT (TO DELAY & WIDTH CIRCUITS)
+2V min. all freq. +40nsec 0V
2V min. TO 15V max.
Q105 2N741
R120 47Ω
C105 .01
R121 910Ω
-1.5V
.4V
R124 300Ω
Q108 2N741
-7V
-12V
R129 560Ω
C111 500pF
R136 220Ω
Q109 2N7068
CR112 IN270
R135 4.7K
R138 33Ω
⑨ TRIGGER OUTPUT
R137 430Ω
R130 56Ω
R127 2.7K
C110 250pF
R131 510Ω
5V
OPEN CKT. 2.5V TERMINATED IN 50Ω
0V
50n Sec
R128 1K
.4V
+22V
R133 8.2K
.05V
C109 150pF
R134 560Ω
③ EXT DRIVE
R132 100Ω
CR111 IN 2941 TUNNEL DIODE (Imax.=25MA)
Q107 2N741
R125 43Ω
R126 510Ω
C108 250pF
.01μsec
.3V min.
-2.6V
0V
2V min. TO 15V max.
-2.5V
+22V
C112 .1
C116 25 μF 25V
C113 .1
C117 25 μF 25V
C114 .1
C118 25 μF 25V
C115 .1
C119 25 μF 25V
⑦ -7.5V
⑩ -5V
① ② ⑰ ⑱
⑤ -2.5V
⑧ +22V

④ GATE IN
FREE-RUNNING MULTIVIBRATOR Q 101, 102, 103
GATE Q 104
OUTPUT EMITTER FOLLOWER Q 106
⑥ TO DELAY & WIDTH ONE-SHOTS
EXT. DRIVE TRIGGER SHAPER CR 111, Q 105, 107
③ EXT. DRIVE IN
TRIGGER OUTPUT SHAPER Q 108, 109
⑨ TRIGGER OUT (SYNC.)

BLOCK DIAGRAM

NOTES:
1.) WAVE FORMS TAKEN WITH FREQ. RANGE SW. SET AT 0.3-1MC; OBSERVED ON TEKTRONIX 541 SCOPE WITH "L" PLUG-IN.

QTY ON 1	ITEM NO.	PART NO.	DESCRIPTION	SCHEMATIC OR SPEC. REF.

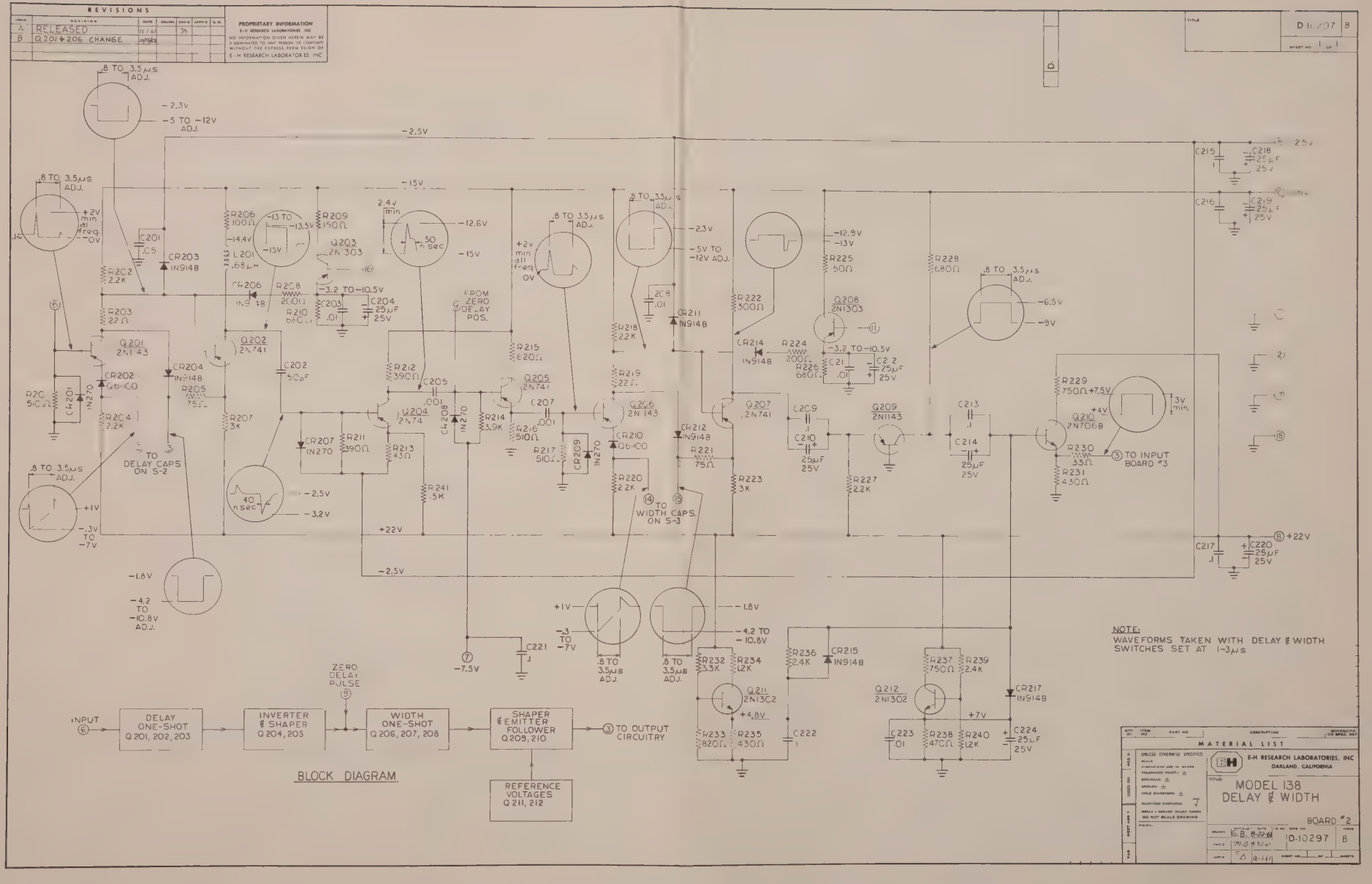
MATERIAL LIST

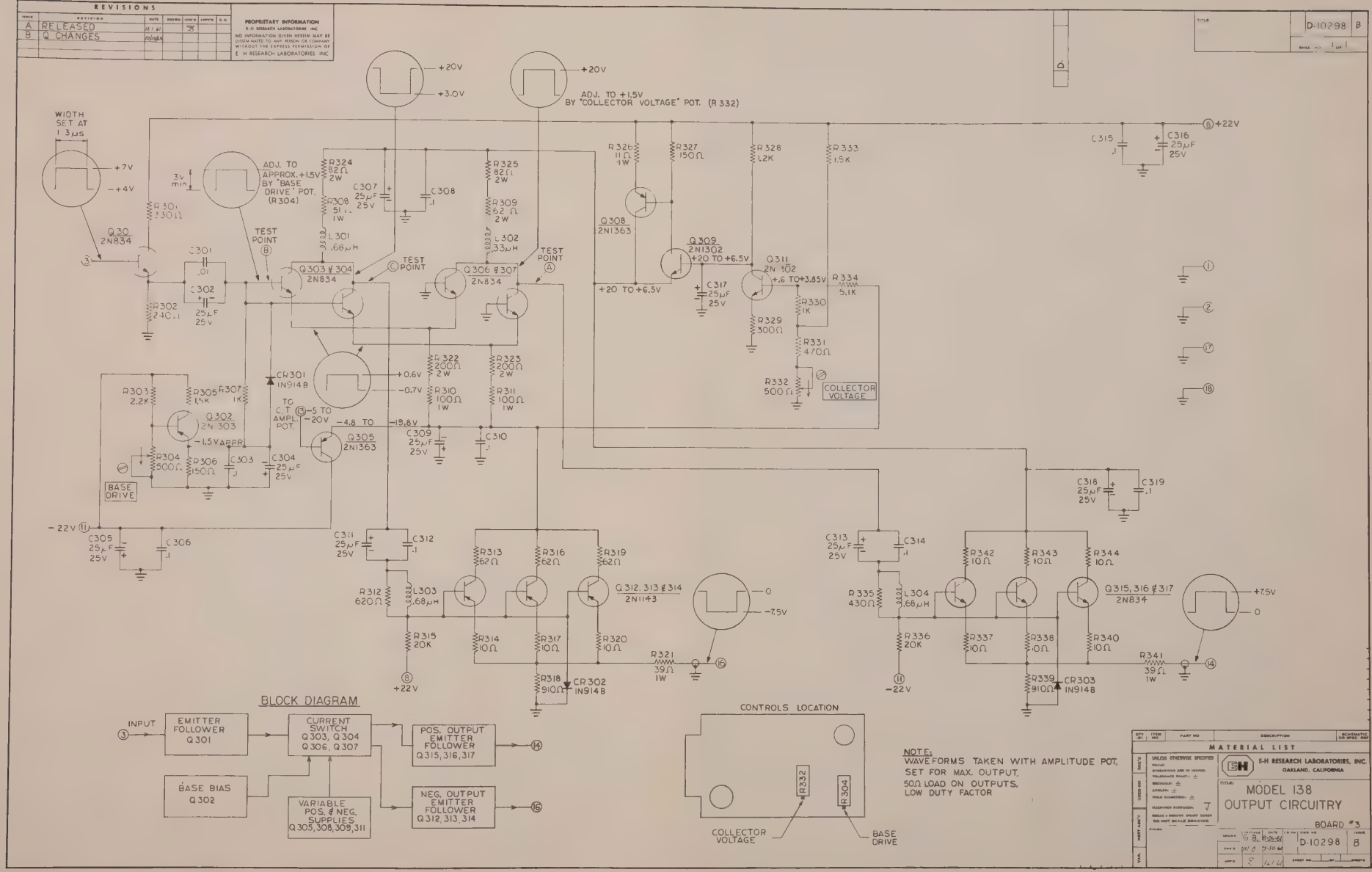
UNLESS OTHERWISE SPECIFIED
SCALE:
DIMENSIONS ARE IN INCHES
TOLERANCE FRACT: ±
DECIMALS: ±
ANGLES: ±
HOLE DIAMETERS: ±
MACHINED SURFACES:
BREAK 4 REMOVE SHARP EDGES
DO NOT SCALE DRAWING
FINISH:

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

TITLE
MODEL 138
MULTIVIBRATOR, GATE & EXT. DRIVE
BOARD #1

	INITIALS	DATE	T.O. NO.	DWG. NO.	ISSUE
DRAWN	G.B.	8-15-61		D-10296	B
CHK'D	MB	9-20-61			
APP'D		10-1-61		SHEET NO. 1 OF 1 SHEETS	


REVISIONS
PROPRIETARY INFORMATION
E-H RESEARCH LABORATORIES, INC
A RELEASED
B Q201+206 CHANGE
D 10297 B
.8 TO 3.5 μs ADJ.
-2.3v
-5 TO -12v ADJ.
-2.5V
-15V
+2v min all freq 0V
-12.6v
50 n sec
-13 TO -13.5V
-14.4v
2.4v min
-12.9v
-13v
-3.2 TO -10.5v
-6.5v
-9v
+22V
+25v
+4v
3v min.
+1v
-.3 TO -7v
-1.8v
-4.2 TO -10.8v ADJ.
-7.5v
-3.2v
40 n sec
TO DELAY CAPS ON S-2
TO WIDTH CAPS. ON S-3
FROM ZERO DELAY POS.
TO INPUT BOARD #3
Q201 2N1143
Q202 2N741
Q203 2N303
Q204 2N74
Q205 2N741
Q206 2N 143
Q207 2N741
Q208 2N1303
Q209 2N1143
Q210 2N706B
Q211 2N1302
Q212 2N1302
R206 100Ω
R209 150Ω
R2C2 2.2K
R203 22Ω
R2C8 200Ω
R210 68Ω
R215 620Ω
R218 2.2K
R219 22Ω
R222 500Ω
R225 50Ω
R228 680Ω
R224 200Ω
R226 680Ω
R229 750Ω
R230 33Ω
R231 430Ω
R2C1 510Ω
R2C4 2.2K
R205 75Ω
R207 3K
R212 390Ω
R214 3.9K
R216 510Ω
R217 510Ω
R220 2.2K
R221 75Ω
R223 3K
R227 2.2K
R241 .5K
R211 390Ω
R213 430Ω
R232 3.3K
R234 12K
R233 820Ω
R235 430Ω
R236 2.4K
R237 750Ω
R239 2.4K
R238 47Ω
R240 12K
C201 .05
C202 50pF
C203 .01
C204 25μF 25V
C205 .001
C207 .001
C208 .01
C209 .1
C210 25μF 25V
C211 .1
C212 .1
C213 .1
C214 25μF 25V
C215 .1
C216 .1
C217 .1
C218 25μF 25V
C219 25μF 25V
C220 25μF 25V
C221 .1
C222 .1
C223 .01
C224 25μF 25V
C21 .01
C2.2 25μF 25V
CR201 IN270
CR202 G6-100
CR203 IN914B
CR204 IN914B
CR206 IN 18
CR207 IN270
CR208 IN270
CR209 IN270
CR210 G6-100
CR211 IN914B
CR212 IN914B
CR214 IN914B
CR215 IN914B
CR217 IN914B
L201 .68 μH
INPUT
DELAY ONE-SHOT Q 201, 202, 203
INVERTER & SHAPER Q 204, 205
ZERO DELAY PULSE
WIDTH ONE-SHOT Q 206, 207, 208
SHAPER & EMITTER FOLLOWER Q 209, 210
TO OUTPUT CIRCUITRY
REFERENCE VOLTAGES Q 211, 212
BLOCK DIAGRAM
NOTE:
WAVEFORMS TAKEN WITH DELAY & WIDTH SWITCHES SET AT 1-3 μs
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC
OAKLAND, CALIFORNIA
MODEL 138
DELAY & WIDTH
BOARD #2
D-10297
B


REVISIONS
A RELEASED
B Q CHANGES
PROPRIETARY INFORMATION
E-H RESEARCH LABORATORIES INC.
D-10298 B
+20V
+3.0V
ADJ. TO +1.5V BY "COLLECTOR VOLTAGE" POT. (R 332)
WIDTH SET AT 1.3μs
+7V
−+4V
3V min
ADJ. TO APPROX. +1.5V BY "BASE DRIVE" POT. (R304)
TEST POINT
Q30 2N834
R301 330Ω
R302 240Ω
C301 .01
C302 25μF 25V
R324 82Ω 2W
R325 82Ω 2W
C307 25μF 25V
C308 .1
R308 51Ω 1W
R309 62Ω 2W
L301 .68μH
L302 .33μH
Q303 & 304 2N834
Q306 & 307 2N834
R326 11Ω 1W
R327 150Ω
R328 1.2K
R333 1.5K
C315 .1
C316 25μF 25V
+22V
Q308 2N1363
Q309 2N1302 +20 TO +6.5V
Q311 2N 302 +.6 TO +3.85V
C317 25μF 25V
R334 5.1K
R330 1K
R329 300Ω
R331 470Ω
R332 500Ω
COLLECTOR VOLTAGE
R322 200Ω 2W
R323 200Ω 2W
R310 100Ω 1W
R311 100Ω 1W
+0.6V
−0.7V
CR301 IN914B
TO C.T. AMPL. POT.
−5 TO −20V
−4.8 TO −19.8V
R303 2.2K
R305 1.5K
R307 1K
Q302 2N 303
−1.5V APPR.
R304 500Ω
R306 150Ω
C303 .1
C304 25μF 25V
Q305 2N1363
C309 25μF 25V
C310 .1
BASE DRIVE
−22V
C305 25μF 25V
C306 .1
C318 25μF 25V
C319 .1
C311 25μF 25V
C312 .1
C313 25μF 25V
C314 .1
R313 62Ω
R316 62Ω
R319 62Ω
R312 620Ω
L303 .68μH
Q312, 313 & 314 2N1143
0
−7.5V
R315 20K
R314 10Ω
R317 10Ω
R320 10Ω
R321 39Ω 1W
R318 910Ω
CR302 IN914B
+22V
R342 10Ω
R343 10Ω
R344 10Ω
R335 430Ω
L304 .68μH
Q315, 316 & 317 2N834
+7.5V
0
R336 20K
R337 10Ω
R338 10Ω
R340 10Ω
R341 39Ω 1W
R339 910Ω
CR303 IN914B
−22V
BLOCK DIAGRAM
INPUT
EMITTER FOLLOWER Q301
CURRENT SWITCH Q303, Q304 Q306, Q307
POS. OUTPUT EMITTER FOLLOWER Q315, 316, 317
BASE BIAS Q302
VARIABLE POS. & NEG. SUPPLIES Q305, 308, 309, 311
NEG. OUTPUT EMITTER FOLLOWER Q312, 313, 314
CONTROLS LOCATION
R332
R304
COLLECTOR VOLTAGE
BASE DRIVE
NOTE:
WAVEFORMS TAKEN WITH AMPLITUDE POT. SET FOR MAX. OUTPUT.
50Ω LOAD ON OUTPUTS.
LOW DUTY FACTOR
MATERIAL LIST
E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA
MODEL 138
OUTPUT CIRCUITRY
BOARD #3
D-10298
B

REVISIONS						
ISSUE	REVISION	DATE	DRAWN	CHECK	APPVD	C.N.
A	RELEASED	12/61				

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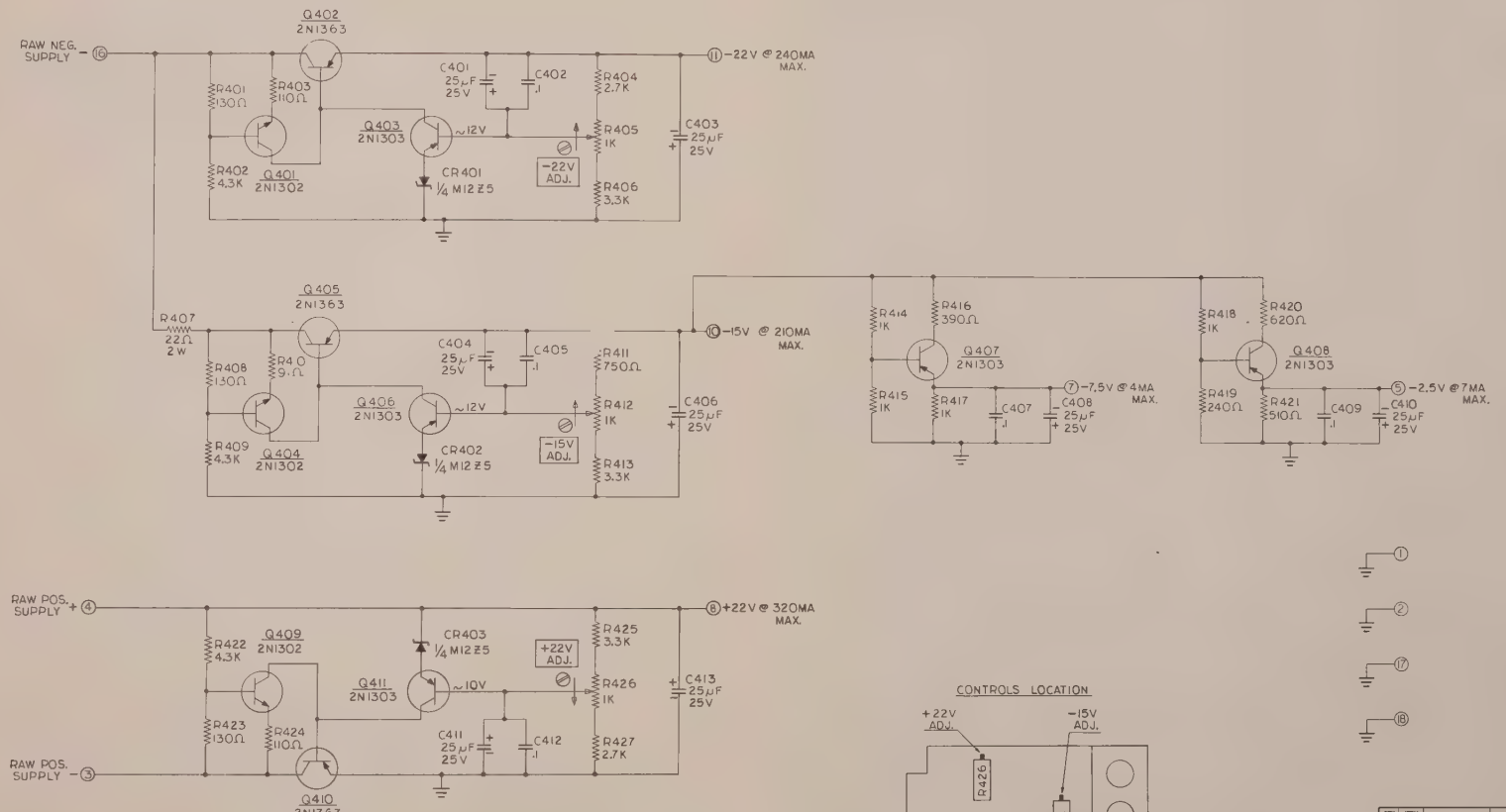
D-10299 A

SHEET 1 OF 1



NOTES:
1.) POWER SUPPLY REGULATES FROM 105 125V A.C. INPUT
2.) TYP. RIPPLE = 15MV P. TO P.

MATERIAL LIST

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

MODEL 138
POWER REGULATORS
BOARD #4

DRAWN	G.B.	9-30-61	D-10299	A
CHK'D		9-23-61		
APP'D		12-1-61		

REVISIONS						
ISSUE	REVISION	DATE	DRAWN	CHK'D	APP'D	E.O.
A	RELEASED	12-1-61		D		
B	R41 & NOTE ADDED	1/16/62				

PROPRIETARY INFORMATION
E-H RESEARCH LABORATORIES, INC.
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D-10300 B

SHEET NO. 1 OF 1

* BOARD #1 | BOARD #2 | BOARD #3 | BOARD #4

EXT. DRIVE INPUT
GATE INPUT
TRIGGER OUTPUT

-2.5 V
-7.5 V
+22 V
-15 V
-22 V

FINE R5 1K 2W
R6 510Ω
FINE R7 1K 2W
R8 430Ω
FINE R9 510Ω
R10 1K 2W
R11 430Ω
AMPLITUDE R12 120Ω
R13 1K 2W
R14 330Ω

R1 5Ω 3W
R2 5Ω 3W
R3 5Ω 3W
R4 5Ω 3W
C1 250μF 50V
C2 250μF 50V
C3 250μF 50V
C4 250μF 50V

CR-1,2,3 & 4 IN2071
CR-5,6,7 & 8 IN2071
R41 390
LT-1

115V A.C.
F-1 0.5A
POWER ON-OFF SWITCH
T-1
YEL. 28V A.C. YEL.
BLK.-RED
BLK.-GRN.
BLK.-YEL.
BLK.
GRN. 28V A.C. GRN.

PRIMARY CONNECTION OF TRANSFORMER FOR 220V A.C. (F-1 = 0.25A)
220V A.C.
REPLACE R1 & R3 WITH BUS WIRE

S1 FREQ. RANGE
EXT.
.3—1KC 2.5
1—3KC .7
3—10KC .25
10—30KC .07
30—100KC .025
100—300KC .007
.3—1MC .0025
1—3MC 600pF
3—10MC 100pF
7-45pF
C5 THRU C14

ZERO
.05—.1
.1—.3
.3—1
1—3
3—10
10—30
30—100
100—300
300—1000
DOUBLE PULSE / SINGLE PULSE
.01
MODIFICATION FOR DOUBLE PULSE GENERATION SEE SEC. 5, "APPLICATIONS"

S2 DELAY μ sec.
7-45pF
150pF R15 51Ω
500pF R16 33Ω
.002 R17 10Ω
.006 R18 5Ω
.02
.06
.2
.6
2.0
C15 THRU C24

S3 WIDTH μ sec.
.05—1
7-45pF
150pF R19 51Ω
500pF R20 33Ω
.002 R21 10Ω
.006 R22 5Ω
.1—.3
.3—1
1—3
3—10
10—30
30—100
100—300
300—1000
.02
.06
.2
.6
2.0
C25 THRU C34

S4 NEG. ATTENUATOR
1
3
10
30
NEG. OUTPUT
R23 27Ω 1W
R24 36Ω
R25 27Ω
R26 27Ω
R27 36Ω
R28 27Ω
R29 27Ω
R30 36Ω
R31 27Ω

S5 POS. ATTENUATOR
1
3
10
30
POS. OUTPUT
R32 27Ω 1W
R33 36Ω
R34 27Ω
R35 27Ω
R36 36Ω
R37 27Ω
R38 27Ω
R39 36Ω
R40 27Ω

*NOTE:
LAYOUT OF PIN NUMBERS ON CONNECTOR BOARD VIEWED FROM FRONT PANEL SIDE OF UNIT

QTY REQ	ITEM NO.	PART NO.	DESCRIPTION	MATERIAL OR SPEC. REF.

MATERIAL LIST

UNLESS OTHERWISE SPECIFIED
SCALE:
DIMENSIONS ARE IN INCHES
TOLERANCE FRACT.: ±
DECIMALS: ±
ANGLES: ±
HOLE DIAMETERS: ±
MACHINED SURFACES: √
BREAK & DEBURR SHARP EDGES
DO NOT SCALE DRAWING
FINISH:

NEXT ASSY
USED ON
APP'D

E-H RESEARCH LABORATORIES, INC.
OAKLAND, CALIFORNIA

TITLE:
MODEL 138
POWER SUPPLY, CONNECTOR BOARD & FRONT PANEL—SCHEM.

DRAWN	G. B.	9-12-61	
CHK'D	M. O.	9-23-61	
APP'D	D	12-1-61	

D-10300 B

SHEET NO. 1 OF 1 SHEETS

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